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Polyrhythmic Tapping: Examining the Effectiveness of the Strategy of Organizing Rhythmic Structures through Synthesis

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Abstract
In this study the strategy of organizing rhythmic structures through synthesis is named, and defined, and its procedures are described. Its effectiveness for teaching the execution of 3:2, 4:3, 8:3, 5:4, and 3:5 polyrhythmic structures is examined and described. Pre-test and Post-test Control Group Design was employed to test the effectiveness of the strategy of organizing rhythmic structures through synthesis. The participants of the study were undergraduate students (N = 18) in their second year of study at the Gaziosmanpaşa University Education Faculty's Music Education Department in the fall semester of the 2012-2013 academic year. The Polyrhythmic Tapping Test was used as a measuring instrument. Two tests were employed in this study. The Wilcoxon Signed-Rank Test was employed to analyze the pre-test and post-test data from both the experimental and control groups. The Mann Whitney U Test was used as a one-sided test to determine the variances (for the experimental and control groups) before the experiment and to determine the variances after the experiment. The results confirm that organizing rhythmic structures through synthesis is an effective way to learn how to perform 3:2, 4:3, 8:3, 5:4, and 3:5 polyrhythmic structures.

Keywords: Polyrhythm • Rhythmic organization • Organizing rhythmic structures through synthesis • Mental metric modulation • Mental pre-rhythmic synthesizing • Polyrhythmic tapping

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The perception and performance of polyrhythms has long been studied by researchers since it includes many difficulties regarding cognition of music and movement control. Polyrhythms require the simultaneous production of incompatible (harmonically unrelated) movement sequences (Krampe, Kliegl, Mayr, Engbert, and Vorberg, 2000). In other words, polyrhythmic performance produces different rhythms at the same time. For example, the 3:2 (3 against 2) polyrhythmic pattern requires one hand to tap twice at equal intervals, while the other hand taps three times in the same length of time.

Studies of polyrhythms show that a variety of strategies or models designed to organize the two hands have been created especially for difficult structures (3:2, 4:3, 5:4, 5:3, etc.) (e.g., Bogacz, 2005; Haken, Peper, Beek, & Daffertshofer, 1996; Jagacinsky, Marshburn, Klapp, & Jones, 1988; Summers, 2002; Summers, Rosenbaum, Burns, & Ford, 1993). These studies are based on two main models: integrated and parallel (e.g., Bogacz, 2005; Jagacinski et al. 1988; Krampe et al. 2000). Integrated models (e.g., integrated chain, integrated hierarchical) represent the flow of two hands on the same line, and these two structures are considered as a whole. In parallel models the flow of each hand in its own motor timing pattern is important, and each pattern in the chain is thought of separately. Some research has claimed that polyrhythmic structures are easier to realize when spontaneous tapping is conceptualized as integrated (Bogacz, 2005; Fidali, Poudrier, & Repp, 2011; Jagacinski et al. 1988; Pressing, Summers, & Magill, 1996; Summers, 2002; Summers & Kennedy, 1992; Summers, Rosenbaum, Burns, & Ford, 1993). However, most research has indicated that the integrated model is the only way or the best model to perform polyrhythmic structures (e.g., Bogacz, 2005; Fidali et al. 2011; Summers, 2002).

In the research, the polyrhythms 2:3, 3:4, 3:5, 4:5, 5:3 and similar polyrhythms are seen as very difficult structures because they cannot be divided equally due to their structural limitations (Deutsch, 1983; Palmer & van de Sande, 1995; Summers, 2002). In the research on polyrhythms or two-handed coordination many authors state that the independent coordination of two hands in polyrhythmic tapping is very difficult (e.g., Klapp, 1979; Klapp, Hill, Tyler, Martin, Klapp, Nelson, & Jagacinsky, 1998; Kurtz & Lee, 2003). On the other hand, it is claimed that pianists can successfully play or tap these challenging polyrhythms at high tempos (Bogacz, 2005; Krampe et al. 2000). In most studies pianists are said to perform polyrhythmic structures using the integrated approach at slow tempos (Deutsch, 1983; Jagacinski et al. 1988; Klapp, 1979; Krampe et al. 2000). However, they perform these structures using the parallel approach at high tempos since it allows for partial independence of the hands (Krampe et al. 2000).

In general, the studies on polyrhythmic performance focus on the relative difficulty of performance, cognitive strategies and playing styles as a function of ratio complexity (Deutsch, 1983). Deutsch (1983) and Summers et al. (1993) arranged different polyrhythms according to their difficulty index (3:2, difficulty index 6; 5:2 difficulty index, 10; 4:3 difficulty index 12; 5:3, difficulty index 15, 9:2, difficulty index 18; 5:4, difficulty index 20) (as cited in Jagacinski, Peper, & Beek, 2000). This difficulty index rises with ratio complexity. Another opinion is that ratio complexity increases difficulty and has a tendency to simplify the production of polyrhythms, especially at high tempos (Peper, Beek, & van Wieringen, 1995). In his study to determine the relationship between tempo and polyrhythmic patterns, Bogacz (2005) found that performance does not fall as the tempo increases within 3:5 polyrhythm. On the contrary, this polyrhythmic structure becomes more difficult to execute as the tempo decreases. However, he determined that the 5:3 polyrhythmic pattern becomes more difficult to play when 5:3, 3:2 and 2:1 polyrhythmic patterns are played interchangeably.

The models used in research on difficult polyrhythmic structures are based on cognitive processes. A kind of rhythmic organization is used to enhance the performance of these structures. Rhythmic organization strategies are learning strategies that make sense of musical material by restructuring and organizing it (Yokuş & Yokuş, 2010). However, the rhythmic organization of musical creations is important insofar as it allows for a true reflection of musical expression and makes it easier to play instruments. This study uses a cognitive approach to organize the notation of polyrhythmic patterns using an alternative strategy that allows the structures that cannot be divided into equal durations to be divided equally in themselves. The authors of this paper call this the strategy of organizing rhythmic structures through synthesis.

The strategy of organizing rhythmic structures through synthesis is an alternative strategy for polyrhythmic structures that seem too complex or difficult to play at first glance, for a long length of

time, or are unsuitable for being divided into two or three durations and thus divided into different forms. This strategy enables these structures to be synthesized and expressed in organized partitions. The operational phases of the strategy are: 1- Calculating the least common denominator of the polyrhythm, 2- Determining the units, 3- Matching the units with suitable notations, 4- Classifying the note forms included in the structures, 5- Arranging the grouped units according to the writing of the meter that will represent the main beat, 6- Identifying the relationship between the polyrhythmic structure and the new structure, 7- Doing the mental pre-rhythmic synthesizing, and 8- Applying the rhythm strategy using the integrated hierarchical approach to the new structure.

The authors used mental pre-rhythmic synthesizing in the operational phases of the strategy and gave it this name because performance of the polyrhythm requires a preliminary mental preparation. Preparation and a reminder for the new tapping structure are applied along with a suitable partition shape, and this rhythm is counted in the mind during performance.

The strategy of organizing rhythmic structures through synthesis is an alternative cognitive strategy for difficult polyrhythmic structures that require advanced education to play or tap. This strategy prevents these structures from not being divided equally in terms of notation and divides them equally. Thus, it appears that the difficulty of playing or tapping of these structures can be minimized through rhythmic organization by synthesizing them.

This study is based on this notion and its research statement is, "How does the strategy of organizing rhythmic structures through synthesis affect the performance of 3:2, 4:3, 8:3, 5:4 and 3:5 polyrhythmic structures?" The goal is to make a synthesis of the relevant literature, to define a new dimension of rhythmic organization and test its efficiency by synthesizing the difficult 3:2, 4:3, 8:3, 5:4 and 3:5 polyrhythmic structures so that they can be learned and performed quickly. This study advances a new way of learning that helps to overcome the rhythmic difficulties in music education. In accordance with these aims, the hypotheses below are tested.

Hypothesis 1

H_0: There is no significant difference between the scores of the experimental and control groups on the polyrhythmic tapping test.

$H_{1:}$ There is a significant difference between total scores of the experimental and control groups on the polyrhythmic tapping test.

Hypothesis 1.1

H_0: There is no significant difference between pre-test scores of the experimental and control groups on the polyrhythmic tapping test.

$H_{1:}$ There is a significant difference between pre-test scores of the experimental and control groups on the polyrhythmic tapping test.

Hypothesis 1.2

H_0: There is no significant difference between the pre-test and post-test scores of the experimental group on the polyrhythmic tapping test.

$H_{1:}$ There is a significant difference between the pre-test and post-test scores of the experimental group on the polyrhythmic tapping test.

Hypothesis 1.3

H_0: There is no significant difference between the pre-test and post-test scores of the control group on the polyrhythmic tapping test.

$H_{1:}$ There is a significant difference between the pre-test and post-test scores of the control group for the polyrhythmic tapping test.

Hypothesis 1.4

H_0: There is no significant difference between the post-test scores of the experimental and control groups because the experimental group does not improve its performance.

$H_{1:}$ There is a significant difference between the post-test scores of experimental and control groups because the experimental group does improve its performance.

Method

Research Model

This study used an experimental method with the aim of testing the effectiveness of the strategy of organizing rhythmic structures through synthesis. The study used a randomized pre-test and post-test control group design.

Population

The research population consisted of undergraduate students (N = 18) who were in their second year of study at Gaziosmanpasa University's Faculty of Education in the Department of Fine Arts

Education's Music Education Program during the Fall semester of 2012-2013 academic year, and they participated in the study voluntarily. The students had practiced polyrhythmic structures before, but they had not yet studied 3:2, 4:3, 3:4, 5:4 and 3:5 polyrhythmic structures.

To determine whether the research populations were equal in terms of the chosen variable, pre-test results of the "Polyrhythmic Tapping Test" were considered. After the result of the students was analyzed, experimental (n = 9) and control (n = 9) groups were created using a random assignment model.

Certain measurements of both groups were made before and after the experiment. Table 1 shows the research's randomized pre-test and post-test control group design.

Table 1
Study Design

Groups	Pre-test	Application	Post-test
Experi-mental	Poly-rhyth-mic tapping test	Learning the strategy of organizing rhythmic structures through syn-thesis and practicing for the polyrhythmic tapping test	Polyrhyth-mic tapping test
Control	Poly-rhyth-mic tapping test	Training for the normal length of time and practicing for the poly-rhythmic tapping test	Polyrhyth-mic tapping test

The distribution of the students according to their demographical features is shown in Table 2.

Table 2
Distribution of Students Participating in the Research According to Demographics

Demographical features	Experimental n	Control n	*f*	%
Gender				
Girl	6	5	11	61.1
Boy	3	4	7	38.9
Total	9	9	18	100
Type of school				
Fine Arts High School	6	6	12	66.7
Other	3	3	6	33.3
Total	9	9	18	100

As Table 2 shows, the quantitative demographical features of the students are close to each other in terms of gender, and equal in terms of the type of the school from which the students had graduated. Accordingly, it appears that experimental and control groups were equal in terms of demographical features.

The results of the pre-tests applied to both groups were compared to examine the experimental and control groups' performances of 3:2, 4:3, 3:4, 5:4 and 3:5 polyrhythmic structures before the experiment. The parity of the groups' performances was analyzed using the Mann Whitney U Test. The results of this test are shown below:

Table 3
Descriptive Statistics for Pre-test Scores of the Groups on the Polyrhythmic Tapping Test

Polyrhythmic Tapping Test	Pre-test	n	$\overline{X}$	sd
Sub-dimension 1	Experimental Group	9	8.67	1.41
	Control Group	9	9.22	1.72
Sub-dimension 2	Experimental Group	9	10.44	2.83
	Control Group	9	11.22	2.44
Sub-dimension 3	Experimental Group	9	23.44	1.33
	Control Group	9	23.00	3.00
Sub-dimension 4	Experimental Group	9	2.44	3.13
	Control Group	9	3.67	4.30
Test Total	Experimental Group	9	45.00	5.55
	Control Group	9	47.11	9.43

The average score of the experimental group on the polyrhythmic tapping test was $\overline{X}$ = 45.00, and the standard deviation was SD = 5.55. The average score of the control group on the polyrhythmic tapping test was $\overline{X}$ = 47.11, and the standard deviation was SD = 9.43.

The results of the Mann Whitney U test, based on the total pre-test scores of groups from polyrhythmic tapping test, gave no indication of a significant difference between groups (U = 29.00, $p > .05$).

Data Collection Instrument

The researchers used the Polyrhythmic Tapping Test to test the hypotheses of the study.

The Polyrhythmic Tapping Test: This test aims to quantify competency in the performance of 3:2, 4:3, 8:3, 5:4 and 3:5 polyrhythmic structures. The test consists of 4 sub-dimensions of polyrhythmic structures, and the test includes 87 polyrhythmic structures. One point is given for each polyrhythmic structure. The maximum possible score on the test is 87, and the minimum score is 0.

The first sub-dimension is the polyrhythmic structures and variants of 3:2. The second sub-dimension is 4:3 and 8:3. The third sub-dimension is 5:4, and the fourth sub-dimension is 3:5. The test, along with the polyrhythmic structures related to the first and third sub-dimensions, includes 1:1, and 2:1 structures. The third and fourth sub-dimensions, along with the related polyrhythmic structures, include the 1:1, 2:1 and 3:1 polyrhythmic structures. The main purpose of the test is to examine competency in the performance of 3:2,

Table 4
Results of the Mann Whitney U Test Based on Total Pre-test Scores of Groups from Polyrhythmic Tapping Test

Polyrhythmic Tapping Test	Group	n	Rank Average	Rank Total	U	z	p
Sub-dimension 1	Experiment	9	8.22	74.00	29.00	-1.17	.24
	Control	9	10.78	97.00			
Sub-dimension 2	Experiment	9	8.67	78.00	33.00	-.68	.49
	Control	9	10.33	93.00			
Sub-dimension 3	Experiment	9	9.11	82.00	37.00	-.47	.63
	Control	9	9.89	89.00			
Sub-dimension 4	Experiment	9	8.72	78.50	33.50	-.65	.51
	Control	9	10.28	92.50			
Test Total	Experiment	9	8.22	74.00	29.00	-1.02	.30
	Control	9	10.78	97.00			

4:3, 8:3, 5:4 and 3:5 polyrhythmic structures. These structures are designed to contrast with the 1:1, 2:1 and 3:1 structures, so each sub-dimension includes the 1:1, 2:1 and 3:1 structures along with the target polyrhythmic structures.

The first sub-dimension tests tapping of the 3:2 polyrhythmic structure. This sub-dimension includes 22 polyrhythmic structures. In the first sub-dimension items 3, 4, 7, 8, 11, 12, 13, 14, 15, 16, 17 and 18 test the 3:2 polyrhythmic structure, and items 1, 2, 5, 6, 9, 10, 19, 20, 21 and 22 test the 1:1 and 1:2 polyrhythmic structures. The rhythms in items 4 and 5 of the first sub-dimension seem to be written in 6:4 writing; however, these are two 3:2 polyrhythmic structures. The 6:4 polyrhythmic structure in these meters is designed to be scored by counting 3:2 twice. Accordingly, items 11-18 are arranged in this context.

The second sub-dimension tests tapping of the 4:3 and 8:3 polyrhythmic structures. This sub-dimension includes 23 polyrhythmic structures in total. In the second sub-dimension, items 4, 5, 9, 10, 12, 13, 18 and 20 test the 4:3 polyrhythmic structure. Items 11 and 14 test the 8:3 polyrhythm, and the other items (1, 2, 3, 6, 7, 8, 15, 16, 17, 19, 21, 22 and 23) test the 1:1, 2:1 and 3:1 polyrhythmic structures. The rhythms in items 5 and 7 seem to be in 8:6 form; however, this polyrhythmic structure is a doubled 4:3 rhythm. Therefore, these structures are designed to be scored as 4:3. Accordingly, items 9-10 and 12-13 items are 4:3 polyrhythms.

The third sub-dimension tests tapping of the 5:4 polyrhythmic structure. This sub-dimension includes 26 polyrhythmic structures. In the third sub-dimension items 9 and 22 are 5:4 polyrhythms. The other items (1, 2, 3, 4, 5, 6, 7, 8, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 23, 24, 25 and 26) include 1:1 and 2:1 polyrhythmic structures.

Finally, the fourth sub-dimension tests tapping of the 3:5 polyrhythmic structure. This sub-dimension includes 16 polyrhythmic structures. Items 7 and 14 items test the 3:5 polyrhythmic structure. The other items (1, 2, 3, 4, 5, 6, 8, 9, 10, 11, 12, 13, 15, and 16) are 1:1, 2:1 and 3:1 polyrhythmic structures.

The metronome tempo of the first three sub-dimensions of the test is "50" (a quarter note = 50), and the metronome tempo of the fourth sub-dimension is "40" (a quarter note = 40). The 3:2, 4:3, 8:3, 5:4 and 3:5 polyrhythms appear in equal numbers alternately in both hands, and the 3:2 and 4:3 polyrhythms are included in different periods, too.

Table 5
Cyclical Periods of the 3:2, 4:3, 8:3, 5:4 and 3:5 Polyrhythms in Polyrhythmic Tapping Test

Polyrhythm	Sub-dimension	Items	Cyclical Period (millisecond)
3:2	1	3, 4, 11, 12, 13,14, 15, 16, 17, 18	1200
3:2	1	7, 8	2400
4:3	2	4, 5	3600
4:3	2	9, 10,12, 13	1800
4:3	2	18, 20	1200
8:3	2	11, 14	3600
5:4	3	9, 22	4800
3:5	4	7, 14	1500

This 87-item polyrhythmic tapping test was given to first year (n = 25) and second year (n = 18) students in Gaziosmanpasa University's Faculty of Education in the Department of Fine Arts Education's Music Education Program (N = 43). The test aimed to calculate validity and reliability. The test score was the sum of correct (1) and incorrect (0) performances of the polyrhythmic structures. The Kuder Richardson-20 (KR-20) reliability analysis was used to calculate the internal consistency and reliability of the test. The results of the polyrhythmic tapping test are shown in table 6:

Table 6
Internal Consistency Result of the Polyrhythmic Tapping Test

Polyrhythmic Tapping Test	n	n (item number)	$\overline{X}$	sd	KR-20
Sub-dimension 1	43	22	8.65	1.93	0.71
Sub-dimension 2	43	23	10.95	2.66	0.81
Sub-dimension 3	43	26	22.47	4.16	0.96
Sub-dimension 4	43	16	3.53	4.60	0.94
Test Total	43	87	45.60	8.61	0.92

This result indicates that KR-20 reliability coefficient of polyrhythmic tapping test for the sub-dimensions is .71, .81, .96 and .94, respectively, and .92 for the test as a whole. Based on this result, it was determined that the polyrhythmic tapping test successfully measured the competency of the students' performances. The polyrhythmic tapping test was given to the group (N = 18) before and after the experiment.

Task

Based on the research methodology, a two-hour training session was held to teach the practice of the strategy of rhythmic organization through synthesis. The training of this strategy was done with the experimental group by one of the researchers in a separate classroom. Traditional training was given to the control group. In the first lesson the introduction, teaching and practice of 3:2, 4:3, 3:4, 5:4 and 3:5 structures were taught on the same day, but at different times with both groups. The polyrhythmic tapping test was given to both groups after a week of practice. The polyrhythmic tapping test was done with both groups on the same day, but at different times, for the second lesson of the training.

In the lessons on the strategy of rhythmic organization through synthesis mental pre-rhythmic organization, metric modulation, as well as 3:2, 4:3, 8:3, 5:4 and 3:5 polyrhythmic structures were taught to the students. The structure and application of this strategy was taught using the direct instruction approach. The goals of the lesson were explained. The learning strategy that could be applied directed to the related material was explained. The students were given the opportunity to practice this strategy to see whether they had understood the strategy or not, and to provide feedback. The students were given a week to use the strategy independently, and the second lesson was given to both groups to evaluate their achievements, take stock of their situation, correct their mistakes and give the necessary tips. A metronome was used while using the strategy of rhythmic organization through synthesis in the lessons, and the students were asked to practice with a metronome during their individual practice that week.

Evaluation: The groups were individually taken to a classroom, which had been prepared beforehand to do the polyrhythmic tapping test for pre-test and post-test. Each student was asked to sit on a chair and perform the polyrhythmic structures in each dimension with their left and right hand, according to the metronome numbers until they completed the test, accompanied by the metronome and without stopping. To make the sounds of their right and left hand tapping more distinctive, the students were asked to tap with a pencil. After each sub-dimension was finished, the students were asked to stop and resume when they felt ready for the next sub-dimension.

During the polyrhythmic tapping testing, three specialists, including the researchers, evaluated the performances. They were videotaped to be able to eliminate certain problems, such as stopping or stuttering, and to make better evaluations. The evaluations of the three specialists were checked, and in ambiguous situations the video recordings were watched and necessary controls were exercised. Each polyrhythmic structure was scored correct (1) or incorrect (0). Explanations were given to both groups before the pre-test, and a course hour (45 minutes) was used to administer the polyrhythmic tapping test.

Data Analysis

The research used randomized pre-test – post-test control group design, and the data was classified into two groups both in terms of independent variables and according to experimental and control groups. The data of each independent variable was divided into two groups: the experimental and control groups. For the analysis of the pre-test and post-test data acquired from the experimental and control groups, the paired-sample Wilcoxon signed-ranked test was applied to the independent variables. This determined which group made more progress than the other in terms of the independent variable. The Mann Whitney U test was used to

determine the parity of the experimental and control groups' performances before and after the experiment, oriented towards making a one-way analysis of variance (one-way ANOVA) on the pre and post-tests. This test determined which group's performance improved the most.

Findings and Interpretation

In this section, the acquired data was arranged, tabulated and interpreted per the hypotheses of the study.

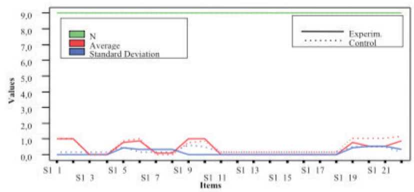
Findings and Interpretation Regarding Hypothesis 1

The total scores of the experimental and control groups for polyrhythmic tapping test are shown on Table 7.

Table 7, shows that the average total score of the experimental group on the polyrhythmic tapping pre-test was $\overline{X}$ = 45.00, and the standard deviation was SD = 5.55; the average pre-test score of the control group was $\overline{X}$ = 47.11, and the standard deviation was SD = 9.43. The average total score of the experimental group on the polyrhythmic tapping post-test was $\overline{X}$ = 85.67, and the standard deviation was SD = 2.35. The average post-test score of the control group was $\overline{X}$ = 49.00, standard deviation was SD = 8.80.

The highest average score on the polyrhythmic tapping test ($\overline{X}$ = 85.67) was achieved by the experimental group, and the lowest average score ($\overline{X}$ = 45.00) was on the pre-test of the experimental group. Pre-test scores from the two groups indicate that their performances were close to each other, and the post-test average scores indicate that the experimental group did much better on the test. Thus, the zero hypothesis is refuted, and the alternative hypothesis is confirmed.

However, it appears that polyrhythmic tapping test sub-dimensions and test total pre-test averages of the experimental and control groups were close to each other. Also, the control group's average score did not increase much on the post-test, while the average score of the experimental group were nearly the highest (sub-dimension 1/$\overline{X}$ = 22, sub-dimension 2/$\overline{X}$ = 23, sub-dimension 3/$\overline{X}$ = 26, sub-dimension 4/$\overline{X}$ = 16) that can be obtained on the test. The reason for this increase can be better understood by analyzing the sub-dimension items of the pre and post-test polyrhythmic tapping test. The average scores and standard deviations of the items on the pre-tests and post-tests are shown in the graphic below.

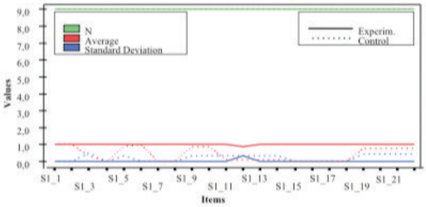


Graphic 1: Descriptive statistics of the groups' pre-test polyrhythmic tapping test's first sub-dimension items.

Table 7
Descriptive Statistics of the Total Scores of Groups from Polyrhythmic Tapping Test

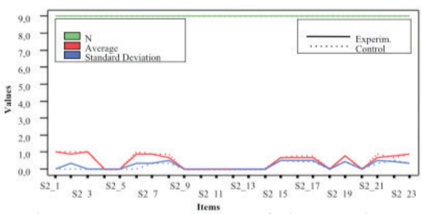
Test	Polyrhythmic Tapping Test	Group	n	$\overline{X}$	sd
Pre-test	Sub-dimension 1	Experimental	9	8.67	1.41
		Control	9	9.22	1.72
	Sub-dimension 2	Experimental	9	10.44	2.83
		Control	9	11.22	2.44
	Sub-dimension 3	Experimental	9	23.44	1.33
		Control	9	23.00	3.00
	Sub-dimension 4	Experimental	9	2.44	3.13
		Control	9	3.67	4.30
	Test total	Experimental	9	45.00	5.55
		Control	9	47.11	9.43
Post-test	Sub-dimension 1	Experimental	9	21.89	.33
		Control	9	9.56	2.83
	Sub-dimension 2	Experimental	9	22.11	1.54
		Control	9	11.11	2.26
	Sub-dimension 3	Experimental	9	26.00	.00
		Control	9	23.33	1.32
	Sub-dimension 4	Experimental	9	15.67	1.00
		Control	9	5.00	4.56
	Test total	Experimental	9	85.67	2.35
		Control	9	49.00	8.80

An analysis of Graphic 1 indicates that the averages of items 3, 4, 7, 8, 11, 12, 13, 15, 16, 17 and 18 were very low or zero for both groups. These items (items 3, 4, 7, 8, 11, 12, 13, 14, 15, 16, 17 and 18) included 3:2 polyrhythmic structures. Accordingly, both groups' level of achievement with 3:2 polyrhythmic structures on the pre-test appeared to be very low. The average scores of both groups for the other items were high.



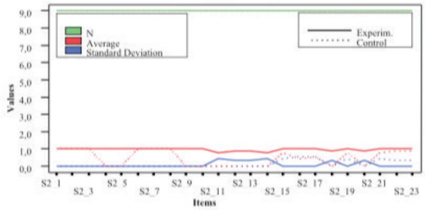
Graphic 2: Descriptive statistics of the groups' post-test polyrhythmic tapping test's first sub-dimension items.

An analysis of Graphic 2 indicates that the experimental group reached the highest level (or came close to this level) on the first sub-dimension of the polyrhythmic tapping test. The control group has very low average scores or zero on items 3, 4, 7, 8, 11, 12, 13, 15, 16, 17 and 18, as they had on the pre-test. An evaluation of Table 7 shows that there is a slight increase between the pre-test and post-test scores of the control group. However, Graphic 2 also indicates that the low total score averages in the first sub-dimension resulted from the 3:2 polyrhythmic structures. Both groups' averages on the other items were high. It may be concluded that the increase in the scores of the experimental group was the result of their successful performance of 3:2 polyrhythmic structures. In other words, from the effectiveness of the strategy of rhythmic organization through synthesis.



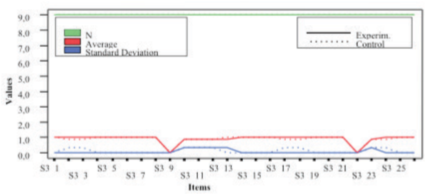
Graphic 3: Descriptive statistics of the groups' pre-test polyrhythmic tapping test's second sub-dimension items.

An analysis of Graphic 3 indicates that average scores for items 4, 5, 9, 10, 11, 12, 13, 14, 18 and 20 were zero for both groups. These items (items 4, 5, 9, 10, 11, 12, 13, 14, 18 and 20) included 4:3 and 8:3 polyrhythmic structures. The score averages of both groups on the other items were high.



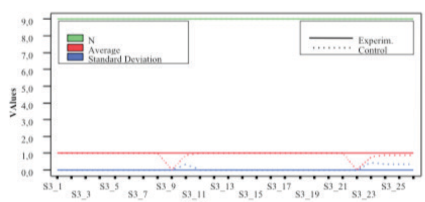
Graphic 4: Descriptive statistics of the groups' post-test polyrhythmic tapping test's second sub-dimension items.

An analysis of Graphic 4 indicates that the experimental group achieved the highest score or came close to it on all items on the post-test polyrhythmic tapping test's second sub-dimension. The control group had a post-test average score of zero on items 4, 5, 9, 10, 11, 12, 13, 14, 18 and 20, as they had on the pre-test. Table 7 shows that the pre-test and post-test scores of the control group were very close to each other. Graphic 4 shows that their average scores on the second sub-dimension did not increase due to items with 4:3 and 8:3 polyrhythmic structures. Both groups' average scores on the other items were either high or close to their pre-test scores. It may be concluded that the higher scores of the experimental group arose from their successful performance of 4:3 and 8:3 polyrhythmic structures. In other words, the strategy of rhythmic organization through synthesis is effective.



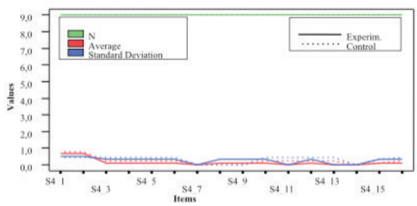
Graphic 5: Descriptive statistics of the groups' pre-test polyrhythmic tapping test's third sub-dimension items.

Graphic 5 indicates that the average score on third sub-dimension items 9 and 22 was zero for both groups. These items (items 9 and 22) appear to include 5:4 polyrhythmic structures. The score averages of both groups on the other items were high.



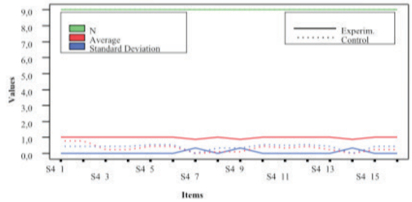
Graphic 6: Descriptive statistics of the groups' post-test polyrhythmic tapping test's third sub-dimension.

Graphic 6 indicates that the experimental group achieved the highest average score on the post-test polyrhythmic tapping test's third sub-dimension. The control group's average scores on items 9 and 22 were near zero, as they were on the pre-test. They had high average scores on the other items. Table 7 shows a slight increase between the pre-test and post-test scores of the control group. Graphic 6 also shows that the average scores of the third sub-dimension remained near zero due to the 5:4 structures in the sub-dimension. Both groups' average scores on the other items were high or close to their pre-test results. It may be concluded that the increase in the scores of the experimental group resulted from their successful performance of 5:4 polyrhythmic structures and the effectiveness of the strategy of rhythmic organization through synthesis.



Graphic 7: Descriptive statistics of the groups' pre-test polyrhythmic tapping test's fourth sub-dimension.

Graphic 7 shows that both groups' pre-test score averages on items 7 and 14 in the polyrhythmic tapping test's fourth sub-dimension were near zero. These items (items 9 and 22) were 3:5 polyrhythmic structures. For the other items, the average scores of both groups were close to each other, and they were low. In this sub-dimension, the average scores of items other than 7 and 14, which included the 3:5 polyrhythmic structure, were low. This was because the sub-dimension includes the 5/8 complex meter, and the students were not familiar with it.



Graphic 8: Descriptive statistics of the groups' post-test polyrhythmic tapping test's fourth sub-dimension.

Graphic 8 shows that the experimental group achieved the highest average score on all items of the polyrhythmic tapping post-test's fourth sub-dimension. The control group's averages for items 7 and 14 were near zero, as they were on the pre-test. Table 7 indicates that there was a slight increase between the pre-test and post-test scores of the control group. However, Graphic 8 shows that the total average scores of the fourth sub-dimension did not increase because of items with 3:5 polyrhythmic structures. The experimental group consistently improved on the other items, and the control group performed much as it did on the pre-test.

It may be concluded that the rise in the scores of the experimental group resulted from their successful performance of polyrhythmic structures, and they owed their success to the effectiveness of the strategy of rhythmic organization through synthesis.

Findings and Interpretation Regarding Hypothesis 1.1

According to the Mann Whitney U test on the groups' pre-test polyrhythmic tapping test scores, there was no significant difference between the groups ($p > .05$). This confirms the zero hypothesis and refutes the alternative hypothesis.

Table 8
Mann Whitney U Test Scores of the Groups Based on the Pre-test Scores of the Polyrhythmic Tapping Test

Polyrhythmic Tapping Test	Group	n	Rank Average	Rank Total	U	z	p
Sub-dimension 1	Experimental	9	8.22	74.00	29.00	-1.17	.24
	Control	9	10.78	97.00			
Sub-dimension 2	Experimental	9	8.67	78.00	33.00	-.68	.49
	Control	9	10.33	93.00			
Sub-dimension 3	Experimental	9	9.11	82.00	37.00	-.47	.63
	Control	9	9.89	89.00			
Sub-dimension 4	Experimental	9	8.72	78.50	33.50	-.65	.51
	Control	9	10.28	92.50			
Test total	Experimental.	9	8.22	74.00	29.00	-1.02	.30
	Control	9	10.78	97.00			

Table 9
Wilcoxon Signed-Rank Test Results of Pre-test and Post-test Scores of the Experimental Group

Polyrhythmic Tapping Test	Experimental Group Post-test – Pre-test	n	Rank Average	Rank Total	*z*	*p*
Sub-dimension 1	Negative Rank	0	.00	.00	-2.71(a)	.007*
	Positive Rank	9	5.00	45.00		
	Equal	0	-	-		
Sub-dimension 2	Negative Rank	0	.00	.00	-2.71(a)	.007*
	Positive Rank	9	5.00	45.00		
	Equal	0	-	-		
Sub-dimension 3	Negative Rank	0	.00	.00	-2.80(a)	.005*
	Positive Rank	9	5.00	45.00		
	Equal	0	-	-		
Sub-dimension 4	Negative Rank	0	.00	.00	-2.69(a)	.007*
	Positive Rank	9	5.00	45.00		
	Equal	0	-	-		
Test total	Negative Rank	0	.00	.00	-2.66(a)	.008*
	Positive Rank	9	5.00	45.00		
	Equal	0	-	-		

(a) Based on the negative ranks; $*p < .05$

Findings and Interpretation Regarding Hypothesis 1.2

The Wilcoxon test on the experimental group's pre-test and post-test results on the polyrhythmic tapping test reveals a significant difference ($p < .05$). This confirms the zero hypothesis and refutes the alternative hypothesis. These results indicate that using the strategy of rhythmic organization through synthesis to learn 3:2, 4:3, 8:3, 5:4 and 3:5 polyrhythmic structures is effective.

Findings and Interpretation Regarding Hypothesis 1.3

The Wilcoxon test on the control group's pre-test and post-test scores on the polyrhythmic tapping test found no significant difference ($p > .05$). This confirms the zero hypothesis and refutes the alternative hypothesis. These results indicate that there was no significant increase in the polyrhythmic tapping test performance level of the control group.

Table 10
Results of the Wilcoxon Signed-Rank Test on the Scores of the Control Group from the Pre-test and Post-test

Polyrhythmic Tapping Test	Experimental Group Post-test – Pre-test	n	Rank Average	Rank Total	*z*	*p*
Sub-dimension 1	Negative Rank	1	3.50	3.50	-.55(a)	.58
	Positive Rank	3	2.17	6.50		
	Equal	5				
Sub-dimension 2	Negative Rank	4	3.88	15.50	-.25(b)	.79
	Positive Rank	3	4.17	12.50		
	Equal	2				
Sub-dimension 3	Negative Rank	2	1.50	3.00	.00(c)	1.00
	Positive Rank	1	3.00	3.00		
	Equal	6				
Sub-dimension 4	Negative Rank	1	1.50	1.50	-1.28(a)	.19
	Positive Rank	3	2.83	8.50		
	Equal	5				
Test total	Negative Rank	5	3.00	15.00	-.42(a)	.67
	Positive Rank	3	7.00	21.00		
	Equal	1				

(a) Based on the negative ranks
(b) Based on the positive ranks
(c) The total of negative ranks is equal to the total of positive ranks

Table 11
Results of Mann Whitney U Test Based On Total Post-test Scores of Groups from Polyrhythmic Tapping Test

Polyrhythmic Tapping Test	Group	n	Rank Average	Rank Total	U	z	p
Sub-dimension1	Experimental	9	14.00	126.00	.000	-3.81	.000*
	Control	9	5.00	45.00			
Sub-dimension 2	Experimental	9	14.00	126.00	.000	-3.65	.000*
	Control	9	5.00	45.00			
Sub-dimension 3	Experimental	9	14.00	126.00	.000	-3.90	.000*
	Control	9	5.00	45.00			
Sub-dimension 4	Experimental	9	14.00	126.00	.000	-3.74	.000*
	Control	9	5.00	45.00			
Test total	Experimental	9	14.00	126.00	.000	-3.62	.000*
	Control	9	5.00	45.00			

* $p < .001$

Findings and Interpretation Regarding Hypothesis 1.4

According to the Mann Whitney U test results, based on total post-test scores of the groups from the polyrhythmic tapping test, there was a significant difference between the groups in terms of all sub-dimensions and on the test as a whole. The experimental group did better on the test ($p < .001$). Thus the zero hypothesis was refuted, and the alternative hypothesis was confirmed. This indicates that the strategy of rhythmic organization through synthesis is an effective way to teach the performance of 3:2, 4:3, 8:3, 5:4 and 3:5 polyrhythmic structures.

Discussion

Music and instrument education is a complicated process that requires the inclusion of various techniques, methods and strategic information. One should understand how learning can be effective and permanent, and realize that planne learning is vital for attaining such effectiveness and permanence (Yokuş & Yokuş, 2010). Learning strategies are the ways to be chosen and followed, or the methods to be used. Learning strategies, or cognitive strategies, offer different ways of thinking to students in order for them to learn and remember knowledge (Gagne & Driscoll 1988). Many studies in a variety of educational fields indicate that the use of learning strategies very effectively helps students learn how to organize and control their own learning (e.g., Schunk & Gunn, 1986; Tunçer, 2007; Uyar, 2008; Yokuş, 2009a; Yokuş, 2009b). These strategies can facilitate students' development of learning skills with a variety of activities.

This study names and defines the effectiveness of the strategy of rhythmic organization through synthesis, and explains the use of this strategy in 3:2, 4:3, 8:3, 5:4 and 3:5 polyrhythmic structures. In the context of the study researchers taught this strategy to students, and then evaluated whether there was an improvement in students' performance levels with 3:2, 4:3, 8:3, 5:4 and 3:5 polyrhythmic structures. Based on the results of the research hypothesis, a significant difference was found between the polyrhythmic tapping test scores of the experimental and the control groups. The experimental group was better able to perform 3:2, 4:3, 8:3, 5:4 and 3:5 polyrhythmic structures. This result indicates that the strategy of rhythmic organization through synthesis is an effective way to learn how to perform 3:2, 4:3, 8:3, 5:4 and 3:5 polyrhythmic structures.

Jagacinski et al. (1988) studied 3:2 polyrhythmic pattern performance, and they claim that an integrated analytical hierarchy process is superior to a serial supply chain. The study sample was asked to listen to polyrhythmic structures in an integrated form, and it was found that the group can perform these structures with less variation when they listen to them in an integrated form. Kurtz and Lee (2003) did a study of the perceptual-motor practice of partial and integrated 2:3 polyrhythmic structures, and they found that the group practicing an integrated perceptual-motor study performed the polyrhythm with more ease. Since this study used the integrated analytical hierarchical process as a rhythmic organization strategy for tapping 3:2, 4:3, 8:3, 5:4 and 3:5 polyrhythmic structures, it appears that the results support the conclusions reached by Jagacinski et al. (1988) and Kurtz and Lee (2003).

Nonetheless, a review of the literature indicates that there are also arguments that prioritize the development of psychomotor skills oriented to the performance of polyrhythmic structures. For example, in the context of a response to a

reader's question about 2 against 3 and similar combinations, Magrath (2005) suggested playing the C major scale with the right hand for rising and falling triple structures, while the left hand plays Alberti bass in sixteenth notes using C major chord tones, and then repeating the process. She also suggests that the same practice can later be repeated in E major. In addition, she suggests that these units should be combined slowly while feeling the beat to gain these skills; and learning them on auto-pilot or as a psycho-motor skill by paying attention to the melodic structure as a whole. These ideas indicate that an approach directed to learn polyrhythmic structures does not point out the operation of cognitive processes. However, certain reference books about polyrhythmic structures treat them as the development of psycho-motor skills (e.g., Magadini, 2001; Yavuzoğlu, 2011). However, many studies of the correct performance of polyrhythmic structures claim that practicing these structures as cognitive processes is very effective (e.g., Amazeen, Amazeen, Treffner, & Turvey, 1997; Bogacz, 2005; Jagacinski et al., 1988; Jagacinski et al., 2000; Riley, Amazeen, Amazeen, Treffner, & Turvey, 1997; Treffner and Peter, 2002).

Another study of the performance of polyrhythmic structures by Akyıldız (2007) attempted to determine "the effectiveness levels of polyrhythmic learning approaches for piano, technique and instruction." She claims that a single method is not effective for all polyrhythmic subjects, and that each approach appears to be effective for different subjects. She analyzed polyrhythmic learning strategies in four categories: motor skills, cognitive learning, coordination and verbal. The effectiveness of these strategies in their own areas of difficulty were compared, and it was determined that motor skills and cognitive learning approaches were more effective than coordination and verbal approaches.

In the literature there are also studies that tested the effect of tempo on polyrhythm performance. Bogacz (2005) did an experimental study of 5:3, 3:2 and 2:1 polyrhythmic structures played alternately at different tempos in piano. The participants were asked to memorize a diagram of 5:3 and 5:2 polyrhythms within the duration of the beats, inadequately indicated by the notation. These were practiced until the participants memorized the structures. Their performances did not decline as the tempo rose. On the contrary, the 5:3 polyrhythmic structure became more difficult to play as the tempo slowed.

This study prepared a combined form of the polyrhythmic tapping test for 3:2, 4:3, 8:3, 5:4 and 3:5 polyrhythmic structures along with 1:1 and 2:1, and 3:1 rhythmic structures. The experimental group was more successful than the control group in performing the polyrhythmic structures. This study's strategy effectively taught the correct performance of patterns at different tempos: the 3:2 polyrhythm in the first sub-dimension of polyrhythmic tapping test and the 4:3 polyrhythm in the second sub-dimension of the test.

This research determined that the first sub-hypothesis of the study was valid. The experimental and control groups were equal prior to the experiment. Regarding the second sub-hypothesis of the study, there was a significant difference between the total polyrhythmic tapping test pre-test and post-test scores of the experimental group. This means that the experimental group was very close to the maximum score that could be obtained from the test when the pre-test total scores and the averages of each item in the sub-dimensions of the test were considered, and the 3:2, 4:3, 8:3, 5:4 and 3:5 polyrhythmic structure items are ignored. The group did not successfully perform these polyrhythmic structures when these items are considered alone. However, when considering the post-test average scores and the averages of each item in the sub-dimensions of the test, it appears that this difference resulted from the groups' success in performing the items including 3:2, 4:3, 8:3 5:4 and 3:5 polyrhythmic structures. In other words, it results from the effectiveness of the strategy of rhythmic organization through synthesis.

Considering the third sub-hypothesis of the study, there was no statistically significant difference between the pre-test and post-test total scores of the control group on the polyrhythmic tapping test. These results indicate that there was no significant rise in the level of the control group's performance on the polyrhythmic tapping test. The reason that there was no significant increase between the pre-test and post-test total scores of the control group appears to be the average score of the items that include 3:2, 4:3, 8:3, 5:4 and 3:5 polyrhythmic structures, which was "0" or very low. In other words, tapping 3:2, 4:3, 8:3, 5:4 and 3:5 polyrhythmic structures is quite difficult – after this amount of traditional training. Fidali et al. (2013) did an experimental study on the perception of polyrhythmic structures (2:5, 3:5, 4:5, 6:5, 7:5), and they found that the polyrhythmic structure becomes more difficult to distinguish as the complexity of the structure increases.

Thus, it appears that perceiving or performing polyrhythmic structures might require practicing for a long time if no cognitive strategies are used and only psycho-motor skills are developed.

Regarding the fourth sub-hypothesis of the study, there was a significant difference between the groups' post-test scores on the polyrhythmic tapping test, in all sub-dimensions and for the test as a whole. The experimental group did better on the test. Considering that most of the polyrhythmic structures were hard to perform and a long period of instruction was required to perform them, it is remarkable that the strategy of rhythmic organization through synthesis effectively enables students to learn how to performing these polyrhythmic structures.

In conclusion, the strategy of rhythmic organization through synthesis offers students the chance to perform 3:2, 4:3, 8:3, 5:4 and 3:5 polyrhythmic structures more successfully. In other words, this strategy is effective in the performance of 3:2, 4:3, 8:3, 5:4 and 3:5 polyrhythmic structures.

The correct expression of rhythm, a key element of music, accurately reflects the music's character. The use of strategies in teaching and learning the process of music helps facilitate learning and achieve goals more quickly. Based on the results of this study the researchers suggest that the strategy of rhythmic organization through synthesis be taught in the context of music theory curricula and be used to simplify playing and learning the piano and other instruments.

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